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FREQUENCY, WAVELENGTH AND STANDING WAVE PATTERN MEASUREMENT

Preliminary Information:

Slotted Line: A slotted line is a section of a waveguide that has a longitudinal slot cut into it, designed for measuring the Standing Wave Ratio (SWR). A probe, which can be easily moved along the slot via a mechanical carriage, has a voltage induced on it that is proportional to the electric field strength inside the waveguide. The output of the detector on the probe carriage is connected to a DC milliammeter. The Voltage Standing Wave Ratio (VSWR), denoted as S, is calculated using the maximum and minimum values read from the milliammeter.

$$S = \sqrt{\frac{i_{max}}{i_{min}}}$$

To determine the frequency by calculation, the relationship between frequency and wavelength is utilized. The wavelength of a wave propagating in unbounded free space is $\lambda_o = c/f$ (where $c = 3\times10^8$ m/s is the speed of light). The wavelength of a wave propagating in an air-filled waveguide is calculated from the following relation:

$$\lambda_b = \frac{\lambda_o}{\sqrt{1-\left(\frac{\lambda_o}{\lambda_c}\right)^2}} \qquad (1)$$

In equation (1), λ_c is the cutoff wavelength of the waveguide. For TE_{mn} and TM_{mn} modes in a rectangular waveguide, it is obtained from the equation:

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}} \qquad (2)$$

For the dominant mode (TE_{10}) in a rectangular waveguide with a wide dimension 'a', the cutoff wavelength from equation (2) is found to be $\lambda_c = 2a$. Substituting this result into equation (1) gives:

$$\lambda_b = \frac{\lambda_o}{\sqrt{1-\left(\frac{\lambda_o}{2a}\right)^2}} = \frac{1}{\sqrt{\left(\frac{1}{\lambda_o}\right)^2 - \left(\frac{1}{2a}\right)^2}} \qquad (3)$$

From this, the frequency is calculated as:

$$f = \frac{c}{\lambda_o} = c\sqrt{\left(\frac{1}{\lambda_b}\right)^2 + \left(\frac{1}{2a}\right)^2} \qquad (4)$$

The wavelength in the waveguide, λ_g, can be found by measuring the distance between two successive points of minimum field and multiplying by two.

Experimental Procedure:

1. Standing Wave Ratio and Standing Wave Pattern

1.1. Set up the experimental apparatus as shown in Figure 1.

1.2. Set the detector sensitivity to its maximum.

1.3. Set the attenuator vane to 10°, the slotted-line tuner probe position to 40 mm, and its depth to 16 mm.

1.4. Slowly slide the slotted line and probe detector assembly to the right and left and observe the deflection on the milliammeter. Record the maximum and minimum deflection values and calculate the SWR. Determine and record the positions of two consecutive minimum points.

1.5. Slowly move the probe detector between the two consecutive minima at equal intervals. At each point, read and record the corresponding value from the milliammeter.

1.6. Plot the standing wave pattern.

2. Wavelength Measurement and Frequency Calculation

2.1. In the setup from Figure 1, remove the load consisting of the slotted-line tuner and terminator, and connect a short-circuit element in its place.

2.2. Determine the positions of two consecutive minimum points.

2.3. Determine the wavelength.

2.4. Using equation (3), find the frequency of the signal propagating in the waveguide. (a=22.86 mm)

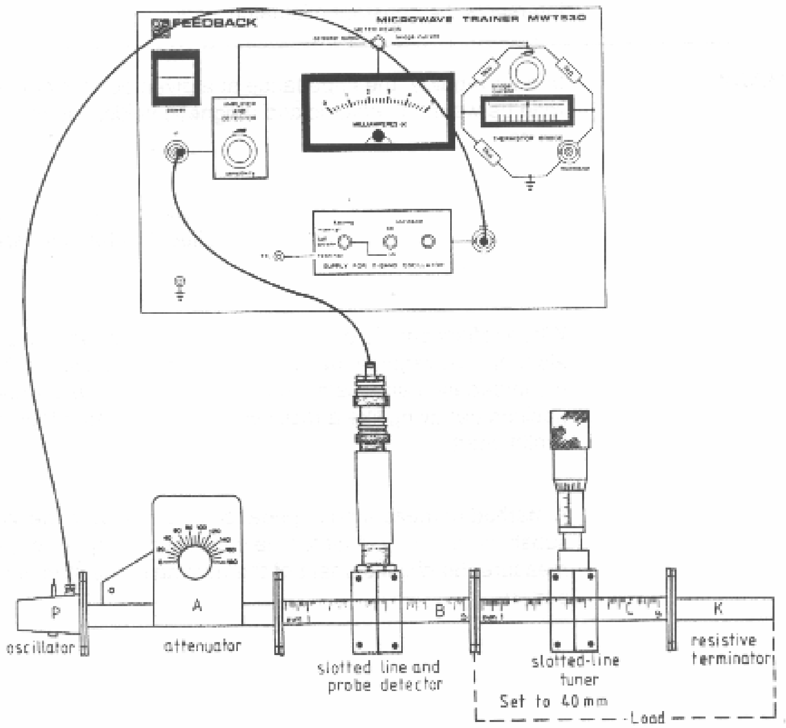

Figure 1: Experimental setup for frequency, wavelength, and standing wave measurement

Questions

1. What is meant by the "dominant mode"? Explain.
2. What is the propagation mode of the waveguide you used in the experiment in the X-band (8.2-12.4 GHz)? Can other modes propagate in this frequency range? Explain.